BELLCOMM, INC.
1100 Seventeenth Street, N.W. Washington, D.C. 20036

SUBJECT: Guidelines for Intermediate Space Station Payloads - Case 710

DATE: July 3, 1968

FROM: F. G. Allen

ABSTRACT

Payloads for earth orbital space stations in the 1970's should be selected to explore and extend manned system capabilities for long duration and reliability while accomplishing as much useful science as possible. Experiment programs in biomedicine, biotechnology and manned operations should have first priority, at least in early missions. Astronomy deserves high priority as a program likely to utilize man well while making major scientific advances. Earth applications may take advantage of manned systems for early R&D operations. Other disciplines of advanced technology, bioscience and physics have useful smaller payloads that are not mission-shaping.

An "Onion Skin" approach is suggested with three optional levels of experiment effort: a hard core of biomedical and operational experiments; next, the addition of a minimum number of useful experiments; and finally a program including significant science.

(NASA-CR-96032) GUIDELINES FOR INTERMEDIATE SPACE STATION PAYLOADS (Bellcomm, Inc.) 12 p

N79-72096

Unclas
00/15 11246

BELLCOMM, INC.
1100 Seventeenth Street, N.W. Washington, D.C. 20036

SUBJECT: Guidelines for Intermediate Space Station Payloads - Case 710

DATE: July 3, 1968

FROM: F. G. Allen

MEMORANDUM FOR FILE

I. INTRODUCTION

This memorandum presents a set of first-order guidelines for assembling multi-discipline experiment payloads for Earth Orbital Space Stations in the 1972-1975 period. A rationale is presented giving agency-wide objectives, priorities among disciplines for manned experiments, and selection criteria. A set of payloads, progressing from "hard core" through "significant science" options is outlined. Principal constraints on payloads are enumerated. Further elaboration of goals and programs in each discipline is then provided in an Appendix.

These guidelines are in general agreement with the outputs of the various NASA disciplinary working groups and with statements of the Planning Steering Group.

II. RATIONALE

A. NASA Goals, Long-range

By the end of the decade (1980) the Agency may well have a National Orbital Space Station with

1) a crew of six men or more,
2) a five-year lifetime,
3) artificial "g" capability.

B. Intermediate Goals

An intermediate space station in the mid-70's will

1) extend the capabilities of manned systems to long-duration reliable operations;
2) validate methods to support man in space and optimize his performance in useful tasks;
3) carry out useful science and technology consistent with or contributing to the above two goals.

C. Priorities by Discipline

In agreement with these goals, primary emphasis will be placed on experiments which investigate, support and develop man's useful role in space. Disciplines will be ranked as they contribute to this end. A first ordering of disciplines on this basis is as follows:

1. Biomedecine (and supporting Bioscience)
2. Biotechnology and Manned Operations
3. Astronomy
4. Earth Applications
5. Advanced Technology (new space hardware and systems)
6. Piggy-back Experiments (Physical Sciences, Bioscience)

Further discussion of each discipline is given in the Appendix.

D. Criteria for Experiments

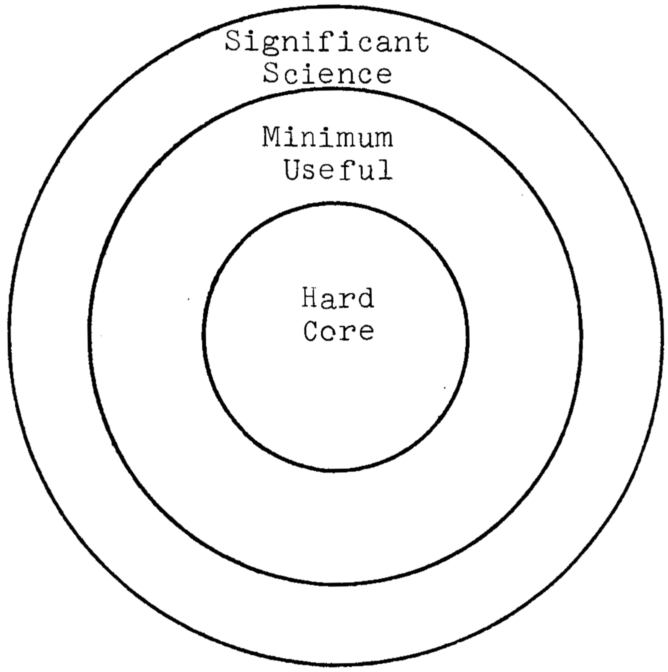
Each experiment must also be judged by

1. the degree to which it takes advantage of the unique capabilities of astronauts or manned systems;
2. the likely contribution of useful knowledge to the space program or to science;
3. technical feasibility and cost effectiveness.

E. Ordered Payload Options (Onion Skin Approach)

Since the level of payload funding and complexity for the intermediate station cannot yet be decided, a set of several options should be drawn up. These should consist of

1. a Hard Core program essential to the mission itself,
2. Hard Core plus Minimum Useful experiment program,
3. Hard Core, plus Minimum Useful, plus Significant Science experiments.



ONION SKIN APPROACH

Suggested guidelines for these options:

1. Hard Core

   A. Biomedical

      i. IMBLMS
      ii. Conditioning exercises

   B. Manned Operations

      i. Piloting S/C, rendezvous, docking
      ii. Set up living quarters, test habitability
      iii. IVA, EVA, tests of supportive devices and hardware, maneuvering units.

2. Hard Core Plus Minimum Useful Experiments

   A. All of Hard Core Program.

   B. More demanding astronaut operations such as assembly, repair calibration, deployment of hardware.

   C. Set up and operate modest set of astronomy experiments, such as small UV, X-ray and gamma-ray telescopes and one or more small solar telescopes.

D. Several useful earth applications experiments such as multispectral imagery of the earth in the visible and the infrared.

Experiments in C. and D. would be selected to provide a variety of skilled manned operations in which performance degradation could be measured.

3. Hard Core, Plus Minimum Useful, Plus Significant Science

A. All of above.

B. An astronomy program equivalent to two ATM telescopes - one stellar-planetary, one solar.

C. A group of four to five earth resources experiments to test and calibrate new techniques.

D. Piggy-back experiments in the advanced technology, physics and bioscience areas.

III. CONSTRAINTS ON PAYLOADS

The outstanding program and mission constraints that must be met in assembling experiments for a given mission are as follows:

A. Schedule

Starting from an assumed flight date (such as 1972 for an early station, 1975 for a new-start) one must assume delivery of flight hardware six to nine months before flight, and can then predict how many years before that experiment definition and development must be accomplished. For a 1972 launch, this restricts available experiments almost to "off-the-shelf items" or at least, to previously developed hardware. Even for 1975, major new hardware systems such as telescopes, may not make the schedule if started now.

B. Costs

Likely expenses required for defining, developing and integrating all experiments for each year through to flight must give totals that could be met in the near term by present budget levels and thereafter. (For example, programs that require experiment funding for FY 1969 of much over $20 million are already impossible.)

C. Weight, Volume and Power

These can be found for a given mission altitude, inclination, lifetime, and resupply schedule. The payload should require a reasonable fraction of the available volume and weight provided by the launch vehicle - neither much less, nor more. Experiment modules may be launched later and docked to the station.

D. Astronaut Time

For assumed 3-, 6- or 9-man crews with house-keeping, piloting and biomedical testing tasks approximately known, the time available for experiments must be matched against estimated experiment requirements. Specialized astronaut training for certain experiments must be considered, along with the various sequences possible for all tasks and experiments. Recent estimates indicate that an astronaut can give about 8 hours per day to biomedical testing and scientific experiments.

E. Mission Parameters and Experiment Requirements

Orbital inclination, altitude, precession rate, radiation levels, earth occultation, pointing attitudes, resupply, and mission duration must all be matched against experiment requirements.

It can be assumed that earth orbital stations in the mid-70's will have

1. Altitude: 150 to 300 n.mi.
2. Inclination: 28-1/2° to 50°
3. Duration: Up to 2 years
4. Resupply: Every 2 to 6 months
5. Facilities for solar, stellar or earth pointing instruments, though perhaps not all at once.

F. Interacting Experiment Requirements

Mutual experiment incompatability of pointing requirements (such as earthward, solar or stellar), EMI, radiation levels, contamination from waste dumps and thruster firings, must be studied, and offending experiments eliminated. Flight of separate experiment modules (astronomy, for example), may be considered as a means of relieving serious conflicts.

F. G. Allen

1015-FGA-caw F. G. Allen

Attachment
Appendix

APPENDIX

DISCIPLINARY OBJECTIVES AND PROGRAMS

A. Biomedicine

Objectives: To determine the effects of the space environment on man for increasing durations up to two years, to develop real time indices of functional impairment and to develop a supportive environment and conditioning procedures to offset the ill effects of space flight and reentry.

Program: For the present this area must receive first priority over all others each time the duration of a mission is extended beyond the previous record (14 days at present). A complete set of tests of bodily status and functions will be carried out at regular intervals using an Integrated Medical Biological Laboratory Measuring System (IMBLMS). A series of conditioning exercises to offset the effects of zero-g must be tested and evaluated. An optimum spacecraft atmosphere must be selected. Habitability conditions must be improved for both living and working. As experience accumulates, the testing time required during the early stages of a prolonged mission can be reduced. Data must be accumulated rapidly during the next few missions to enable an early decision as to whether artificial-g will be desirable in future spacecraft designs. Adequate volume must be provided for living and exercise space per man, and more will be required with longer missions. The volume, weight and power requirements of the IMBLMS apparatus are fairly well established and should not change drastically in the future. Biological experiments with plants or animals directly useful to manned biomedicine problems, should be supported.

B. Biotechnology and MSF Operations

Objectives: To determine the degree of degradation of human performance in space, to develop supporting facilities and procedures to overcome such degradation, and to acquire experience in man's performance of a wide variety of useful space operations, both IVA and EVA, to enable early planning and design to optimize man's role in future space systems.

Program: This program should come close behind Biomedicine in priority for the near future. Unlike Biomedicine, many of the tasks here can and should be designed to fulfill useful science and technology goals while meeting their primary objective of testing man. A carefully planned set of operations is needed testing man's ability to use his mind, to make decisions, to carry them out with simple or complex manual tasks, to maneuver and pilot the spacecraft, to determine his position and orbit, to operate equipment and experiments, to make repairs and adjustments, to handle or filter data, to maneuver about inside or outside the spacecraft, to ensure mission reliability, to test emergency and safety procedures, etc. Supporting hardware such as maneuvering systems, handholds, and zero-g tools must be designed and tested. Complex science experiments requiring man as an operator, and complex spacecraft maneuvers requiring man as a pilot should be carried out and all results noted to provide future design data. Decisions must be made as to how much automation versus manned operation is desirable.

Much of this program should be designed around the useful activities the astronauts should carry out with the spacecraft systems and the scientific experiments themselves. A limited set of test tools and hardware should be provided just for this program in a suitable work area.

Experiments on primates may be justified in both Biotechnology and Biomedicine if they can be scheduled in advance of equivalent manned tests to predict man's medical or functional adaptation to space flight conditions.

C. Astronomy

Objectives: To operate large high-performance, high reliability telescopes above the atmosphere to study radiation from the sun, planets and stars throughout the spectral regions from high energy gamma rays to long-wavelength radio waves.

Program: The advantages of operating in space to avoid the spectral masking and geometric resolution limitations imposed by the atmosphere, together with the importance of astronomy to our understanding of the universe and to our future space program, make this field a high priority space effort. It appears at this time that manned systems can offer important assistance in providing large, expensive high-reliability, long duration versatile telescope systems in space. Hence, a well-planned program in which one or more ambitious telescope system is provided on each manned space station, seems warranted. The proper balance and sequencing between solar, stellar-planetary gamma- and x-ray, radio and optical astronomy must still be worked out. A major question to be resolved is whether or not large telescopes of high resolution can be operated attached to manned stations, or must be flown as free, man-attended modules. Early data on ATM performance should help here. The program should progress through two or three stages of ATM's and perhaps an "ASTRA" to a very large telescope facility (120") in the 1980's. A reasonable balance between the current automated OSO's, OAO's, SAS's and rocket flights, together with the manned program, seems desirable.

The astronomy payloads place special restrictions on the space system. Continuously pointing solar, stellar and planetary telescopes may need to be accommodated, some with image stability of 0.01" or better. Pointing requirements of the telescopes themselves can be less demanding than this if image motion compensation is designed into the optical system. Orbital inclinations of 28° to 60° at altitudes from 200 to 300 N.Mi. satisfy most requirements.

A set of independent inertial platforms with airlocks will accommodate some of the smaller astronomy experiment requirements - for example, UV star surveys, or gamma- and x-ray telescopes.

D. Earth Applications

This field includes all applications of remote monitoring of earth resource information by satellites, covering agriculture, forestry, hydrology, oceanography, geodesy and geology.

Objectives of Manned Program: To assist in early development of new sensing techniques where large multi-discipline payloads and intercomparison of results using complex calibration procedures by astronauts, are important. Also, to determine if man can play a useful role as an observer, choosing special targets of opportunity, or as an on-board data compactor.

Program: Most analyses to date have concluded that while this area may turn out to be a highly rewarding application of space technology, the eventual operating systems should probably be unmanned. The objectives above should therefore guide in choosing early earth resources instrument payloads for manned space stations. A set of IR and microwave imaging instruments, with radar and multispectral visible imaging systems, are candidates. New techniques include use of maneuverable subsatellites for meteorology, that could well be combined with other experiments designed to monitor the physical environment about the manned spacecraft.

The earth resources payloads have a special requirement for a high inclination orbit - preferably 50° or more - to overfly the many calibrated ground truth sites in the United States, as well as to sample a wide range of weather patterns. A low altitude - below 200 N.Mi. - would be desirable for high resolution in some applications. Also, the earth resources instruments must be mounted on an earth-looking platform, one axis of which is always perpendicular to the spacecraft velocity vector for image motion compensation and for radar sweep scans.

Earth resources modules that could be launched from the manned station into polar orbit are of considerable interest and should be studied. Such modules, if available for manned servicing, might qualify as ideal operational earth resources monitoring systems.

E. Advanced Technology

Objectives: To test advanced subsystems and materials in the space environment to provide design data for "next generation" spacecraft.

Program: This program should have less emphasis than some of the above because it is difficult to identify many technology experiments that cannot be done or simulated on the ground. Areas that may prove worthwhile are spacecraft fault location and repair, study of spacecraft environment, micrometeoroid puncture studies and "in-situ" composition analyses, space degradation of materials and surfaces, tests of complex optical systems critically dependent upon zero-g, and deployment in space and use of large structures such as antennas. Tests of subsystem elements where liquids, gases and solids interact and g-forces are normally important (as in fuel cells or elements of life support systems) may also be justified.

The area of communications and navigation, often treated separately, can be grouped with advanced technology. It also does not appear very big or mission-shaping for the manned program.

Tests of lasers, antennas and communications systems should have only limited application for low earth orbiting manned stations. There would be a variety of useful experiments to try if earth-synchronous modules are possible.

G. Bioscience

Objectives: To study significant biological effects peculiar to the space environment (low g, absence of daily cycle and radiation levels), and to develop techniques to apply to later exobiology investigations.

Program: Most of the bioscience program is handled well by automated satellites. Areas that qualify for manned stations are primate experiments, development of zero-g microscope techniques for biological analysis of living matter by astronauts, and other experiments with plants and animals requiring "in-situ" examination of specimens.

H. Physical Sciences

Objectives: To study physical phenomena of space and in space not readily accessible from the ground, balloons or unmanned satellites.

Program: Here again, manned systems are not needed for most of the effort. Three areas that may qualify are 1) a manned laboratory facility on the station carefully designed to study the physics and chemistry of solids, liquids and gases in zero-g; 2) a maneuverable subsatellite operated from the manned station to study the environment of the manned spacecraft in regard to optical, gaseous, plasma, electric and magnetic field environment and to study radiation effects due to spacecraft absorbtion and scattering. The same subsatellite, acting as a slave to the master spacecraft, could do meteorology experiments either to give density measurements by radio occultation or temperature profile measurements by the crossed-beam autocorrelation technique; and 3) a modest high energy cosmic ray facility to do those aspects of high energy physics and astronomy not accessible from balloons or from the high energy accelerators that will be available in the mid-70's. Thus, study of fluxes of electrons, protons and higher z particles at energies less than 10^9 eV will be of interest.

BELLCOMM, INC.

Subject: Guidelines for Intermediate Space Station Payloads - Case 710

From: F. G. Allen

Distribution List

NASA Headquarters

Messrs. W. O. Armstrong/MTX
C. D. Ashworth/SG
M. J. Aucremanne/SG
E. S. Burcher/MTX
R. H. Chase/SG
P. E. Culbertson/MLA
J. H. Disher/MLD
F. P. Dixon/MTY
M. Dubin/SG
J. P. Field/MLP
D. L. Forsythe/MLA
T. E. George/SAB
R. D. Ginter/RF
L. G. Goff/SB
W. L. Green/FD
E. W. Hall/MTG
H. Hall/MTX
L. Jaffe/SA
R. W. Johnson/MTX
T. A. Keegan/MA-2
D. R. Lord/MTD
J. G. Lundholm/MLA
J. A. Mason/MTX
M. E. McDonald/SG
L. N. Mogavero/MTP
B. G. Noblitt/MTY
D. Novik/RFE
L. Reiffel/MA-6
L. Roberts/OART-M (2)
D. P. Rogers/SAE
A. D. Schnyer/MTV
H. J. Smith/SG
R. A. Summers/MTY
P. G. Thome/SF
S. P. Vinograd/MM
M. G. Waugh/MTP
J. W. Wild/MTE
J. R. Wilhelm/MTX
Miss N. G. Roman/SG

Goddard Space Flight Center

Mr. W. G. Stroud/110

Marshall Space Flight Center

Messrs. J. A. Downey/R-SSL-S
J. R. Olivier/R-AS-VO
W. H. Patterson/I-S/AA
W. R. Perry/R-AS-VO
E. Stuhlinger/R-SSL-DIR
G. von Tiesenhausen/R-AS-VO

Manned Spacecraft Center

Messrs. O. K. Garriott/CB
W. E. Hull/DA3
B. G. Jackson/TE
R. O. Piland/AH

Langley Research Center

Messrs. W. N. Gardner/156
G. B. Graves/476
W. R. Hook/156

Bellcomm, Inc.

Messrs. G. M. Anderson
A. P. Boysen, Jr.
D. A. Chisholm
C. L. Davis
D. A. DeGraaf
J. P. Downs
D. R. Hagner
P. L. Havenstein
N. W. Hinners
B. T. Howard
D. B. James
J. Kranton
K. E. Martersteck
R. K. McFarland
J. Z. Menard
G. T. Orrok
I. M. Ross
F. N. Schmidt
J. W. Timko
J. M. Tschirgi
R. L. Wagner
J. E. Waldo

(See next page)

BELLCOMM, INC.

Subject: Guidelines for Intermediate Space Station Payloads - Case 710

From: F. G. Allen

Distribution List (Cont'd)

Bellcomm, Inc. (Cont'd)

All Members Division 101
All Members Department 1021, 1022
Department 1023
Central File
Library